A Department of Ecology Discussion Paper
Water Quality Program
Development Services' Section

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Establishment of an Annual Average Daily Traffic Threshold for Applying Enhanced Treatment (Dissolved Metals Removal)

Introduction:

The 2001 Stormwater Management Manual for Western Washington indicates that runoff from "arterials and highways" should receive "Enhanced Treatment" to achieve improved removal of dissolved metals. The proposed 2004 update to the manual includes a proposal to limit the use of "Enhanced Treatment" to urban roads with greater than 7,500 annual average daily traffic (AADT), and to rural roads and freeways with greater than 15,000 AADT.

There is a general relationship of increasing dissolved metals concentrations with increasing Annual Average Daily Traffic (AADT) (Kayhanian, Singh, Suverkropp, and Borroum, 2003). It is also clear that there is not a reliable linear relationship because of the influence of many other factors in determining runoff concentrations. Other factors found to have a significant effect by Kayhanian et al include: antecedent dry period, seasonal cumulative rainfall, total event rainfall and maximum rain intensity, drainage area, and land use. When the effects of these other factors were considered, the authors found AADT had a significant effect on concentrations of most constituents in highway runoff.

CalTrans Reports:

The largest data set characterizing pollutant concentrations in stormwater runoff from highways is from the California Department of Transportation (CalTrans). Dissolved copper and zinc concentrations from the 2002 – 2003 Caltrans Data Summary Report are summarized below. All CalTrans data reported below are from flow-weighted composite samples taken over a number of hours of a rain event. They are compared to the acute water quality standards for dissolved copper and zinc in fresh water.

The acute standards for these metals are one-hour average concentrations not to be exceeded more than once every three years on average. Most stormwater professionals agree that the acute standards are applicable to stormwater discharges because of the ephemeral nature of rain events. The chronic water quality standards for dissolved copper and zinc are 4-day average concentrations not to be exceeded more than once every three years on average. The chronic criteria, which are lower concentrations, are not usually applied to stormwater concentrations because of their 4-day scope. However, in western Washington, extended storm events of multiple days occur frequently. So, they should not be dismissed as irrelevant.

The CalTrans data is split into two groups:

Urban Highways: Highways which exceed 30,000 AADT

Non-Urban Highways: Highways below 30,000 AADT.

Table 28 from the 2002-2003 Caltrans Annual Data Summary Report is attached. Note the values listed for dissolved Copper and Zinc, the two metals which most commonly exceed water quality standards in urban stormwater runoff.

Table 28: Urban Highway Summary:

Copper:

The mean copper concentration is more than double the acute water quality standard at a hardness of 50 mg/l, and about 5x higher at a hardness of 25 mg/l. Hardness in most areas of western Washington is often within or even below this range. The upper standard deviation value for copper is 5x and 10x the acute standard at 50 and 25 mg/l hardness, respectively.

Examining individual concentrations in a slightly smaller data set from Caltrans yields the following comparisons. At a hardness of 50, 86/114 individual copper measurements would exceed the acute standard for copper, with 15 samples more than 3x the standard. At a hardness of 25, 112/114 individual measurements would exceed the acute standard for copper with 59 samples more than 3x the standard.

Zinc:

The mean zinc concentration is 1.4x the acute water quality standard at a hardness of 50 mg/l, and about 3x higher at a hardness of 25 mg/l. The upper standard deviation value for zinc is more than 4x and 8x the acute standard at 50 and 25 mg/l, respectively.

Again, using a slightly smaller data set, at a hardness of 50, 39/114 individual zinc measurements would exceed the acute standard, but only 5 samples would be more than 3x the standard. At a hardness of 25, 72/114 individual measurements would exceed the acute standard with 19 samples more than 3x the standard.

Calculating the actual number of exceedances in the individual samples would require tracking hardness concentrations for each sample. That information is not provided in the Caltrans report.

Observations:

These data can be used to argue that dissolved metals are of concern for urban highways. The threshold for use of Enhanced Treatment options should be set no higher than 30,000 AADT.

Table 28: Non-Urban Highway Summary:

The mean value of copper for urban highways is 3x higher than for non-urban highways. The mean value of zinc is 2.5x higher.

Copper:

The mean copper concentration is below the acute water quality standard at a hardness of 50 mg/l, and about 1.5x higher at a hardness of 25 mg/l. Hardness in most areas of western Washington is most often within or even below this range. The upper standard deviation value for copper is almost 2x and 4x the acute standard at 50 and 25 mg/l hardness, respectively.

Examining individual concentrations in a slightly smaller data set from Caltrans yields the following comparisons. At a hardness of 50, 29/94 individual copper measurements would exceed the acute standard for copper, but only 1 sample would be more than 3x the standard. At a hardness of 25, 47/94 individual measurements would exceed the acute standard for copper with 10 samples more than 3x the standard.

Zinc:

The mean zinc concentration is below (0.6x) the acute water quality standard at a hardness of 50 mg/l, and above (1.2x) the standard at a hardness of 25 mg/l. The upper standard deviation value for zinc is 1.5x and 2.7x the acute standard at 50 and 25 mg/l, respectively.

At a hardness of 50, 10/94 individual zinc measurements would exceed the acute standard, but only 4 samples would be more than 3x the standard. At a hardness of 25, 29/94 individual measurements would exceed the acute standard with 7 samples more than 3x the standard.

Calculating the actual number of exceedances would require tracking hardness and metals concentrations for each sample. Caltrans did not report the actual number of exceedances.

Observations:

The concentrations for non-urban highways are significantly less than urban highways. But the data still include a significant number of exceedances of the acute water quality standards. A more thorough analysis would be desirable to see if the frequency and magnitude of water quality standards exceedances could be significantly dropped by excluding the higher AADT roads from this broad category of highways less than 30,000 AADT. Without that further analysis, an assumption could be made that eliminating the upper half of this AADT category would reduce the exceedances substantially. That is what is proposed in this manual update.

WSDOT Reports: In the last few years, WSDOT has collected dissolved metals data at a number of sites. Most of those data are from sites well above 30,000 AADT.

WSDOT has monitored one site at an AADT between 14,000 – 18,000. Data reported in earlier annual reports showed 4/10 exceedances of the acute copper standards and 7/10 exceedances of the acute zinc standard. More recent data is inconclusive for copper (the practical quantitation limit for the laboratory analyses was higher than the acute water quality standard), and showed no exceedances for zinc. WSDOT attributes the earlier zinc exceedances to a galvanized slot drain that was used to collect samples.

The WSDOT 2003 annual report includes metals data for a 43,000 AADT highway. 4/11 samples exceeded the acute zinc standard. 6/11 exceeded the acute copper standard.

In its 2004 NPDES Annual Report, WSDOT reported on dissolved metals concentrations prior to and after treatment. At seven sites, ranging from 90,000 to 130,000 AADT, 27/41 stormwater samples exceeded the acute standard for dissolved copper; but only 3 samples were more than 3x the standard. After treatment, 29/41 samples exceeded the acute standard, but only one sample exceeded the standard by more than double. Note that the locations for post-treatment samples were not all the same as the pre-treatment locations

At the same seven locations, 27/41 stormwater samples exceeded the acute standard for dissolved zinc, with 11 exceeding the standard by 2x or greater, but only 1 exceeding the standard by more than 3x. After treatment, 13/41 samples exceeded the acute standard for dissolved zinc, with no samples exceeding the standard by 2x.

Observations:

The WSDOT data tends to generally confirm the concern with dissolved metals at increasing AADT levels. Though a significant number of exceedances of acute copper and zinc standards are reported in the WSDOT 2004 report for high AADT highways, the exceedances are not as high as the CalTrans data. Nearly all samples noted in the 2004 report were taken well into the wet season (December through March). No samples were taken in the dry season (May through September). Lower concentrations of dissolved metals as compared to CalTrans sites may be due, at least in part, to shorter times between rain events (antecedent dry period), and the lack of data during the dry season and the early wet season (referred to as Cumulative Seasonal Precipitation in Kayhanian et al). The time between rain events in July, August, and September is much greater, allowing for greater pollutant build-up. Pollutant concentrations during those times should be higher.

In addition, lower stream flows in summer to early fall provide less ability to provide any possible dilution. In streams draining urban and urbanizing watersheds, where most new development and re-development occur, a significant percentage of the flow in the dry season can be urban stormwater runoff with significant background metals concentrations.

The available WSDOT data seem to support an Enhanced Treatment threshold no higher than 30,000 AADT. The data are sparse and conflicting at around 15,000 AADT. Even with more data, there will likely not be a bright line distinction because of the data scatter due to the influence of other significant factors on pollutant concentrations.

Urban Roads Data

All of the above data are from interurban highways. The Department of Ecology has access to some data from urban roads, but it does not yet have the corresponding AADT for many roads.

The proposal for applying Enhanced Treatment at the 7,500 AADT level for urban roads is based upon a general observation that the primary sources of copper (brakes, bearings, and bushings) and zinc (tires, motor oil, and grease) are subject to higher wear rates on urban roads than on highways. Braking wear and tire wear are increased by lane changes and starts and stops. A 7,500 AADT is ½ of the proposed 15,000 AADT for highways. Rural roads are seen as more similar to highways in regard to the potential for pollutant build-up from traffic.

In order to make a more informed analysis, Ecology requests all local governments share whatever dissolved metals data that they have on roads.

References:

Kayhanian, Masoud, Amardeep Singh, Claus Suverkropp, and Steve Borroum, Impact of Annual Average Daily Traffic on Highway Runoff Pollutant Concentrations, Journal of Environmental Engineering, November 2003.

2002 – 2003 Caltrans Annual Data Summary Report, CTSW-RT-03-069, August 2003.

WSDOT Annual Reports for Compliance with its Municipal Stormwater Permits

For more information

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